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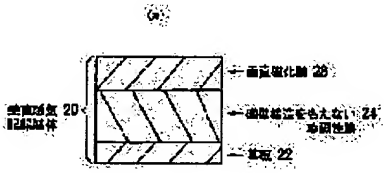
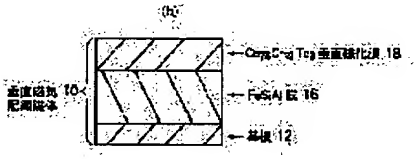
(54) PERPENDICULAR MAGNETIC RECORDING MEDIUM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a perpendicular magnetic recording medium which has an excellent envelope characteristic at the time of recording and reproducing and does not give rise to the contingent noise, demagnetizing or degaussing of recording magnetization occurring in the movement of the magnetic walls of a ground surface soft magnetic film.
SOLUTION: This perpendicular magnetic recording medium 20 has a substrate 22, the ground surface soft magnetic film 24 formed on this substrate and a perpendicularly magnetized film 28 formed on this ground surface soft magnetic film. The ground surface soft magnetic film is composed as a non- magnetic wall structure and the coercive force thereof is ≤300 Oe. Since the ground surface soft magnetic film does not have the magnetic wall structure, the various problems which occur when the ground surface soft magnetic film has the magnetic wall structure, i.e., the contingent noise generated when the perpendicular magnetic head passes above the magnetic walls of the ground surface soft magnetic film, the easy movement of the magnetic walls of the ground surface soft magnetic film by a floating magnetic field and the demagnetizing or degaussing of the recording magnetization are solved. The envelope characteristic is thus improved and low noise is attained.





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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The vertical-magnetic-recording medium which a soft-magnetism film is formed as non-magnetic-domain-wall structure, and is characterized by the coercive force being 300 or less Oes in the vertical-magnetic-recording medium which has at least a substrate, the soft-magnetism film prepared on the substrate, and the perpendicular magnetic anisotropy films prepared on the soft-magnetism film.
[Claim 2] The vertical-magnetic-recording medium according to claim 1 by which a soft-magnetism film is characterized by being formed with FeSiAl or the FeSiAl system alloy.
[Claim 3] The vertical-magnetic-recording medium according to claim 1 by which a soft-magnetism film is characterized by being formed with FeTaN or the FeTaN system alloy.
[Claim 4] The vertical-magnetic-recording medium according to claim 1 by which a soft-magnetism film is characterized by being formed as a granular thin film.
[Claim 5] The vertical-magnetic-recording medium according to claim 4 characterized by forming the granular thin film by either of the matrix elements of the matrix which constituted as a line the material of the particle which SiO2 or C is used [particle] as the base material of a granular thin film, and it considers [particle] as the material of the particle which distributes either Co, CoPt and CoCrPt in a base material, and makes a train and mother existence distribute a base material.
[Claim 6] A vertical-magnetic-recording medium given in any 1 term of the claims 1-5 to which the junction layer of 100nm or less of thickness is characterized by intervening between a soft-magnetism film and perpendicular magnetic anisotropy films.
[Claim 7] The vertical-magnetic-recording medium according to claim 6 characterized by forming the junction layer by either Co1-X Crx (0.25<=x<=0.60), Ti and CrTi.
[Claim 8] A vertical-magnetic-recording medium given in any 1 term of the claims 4-7 to which either Cr film of 500nm or less of thickness, V film and Cu film are characterized by intervening between a granular thin film and a substrate.
[Claim 9] A vertical-magnetic-recording medium given in any 1 term of the claims 4-8 characterized by a granular thin film being non-magnetic-domain-wall structure.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the good vertical-magnetic-recording medium of record reproducing characteristics still in detail about the vertical-magnetic-recording medium used as a magnetic disk etc.
[0002]
[Description of the Prior Art] progress of recent years, a personal computer, or a workstation -- following -- a hard disk drive -- large-capacity-izing -- and since it miniaturizes, the magnetic disk needs the further high side recording density-ization However, if the longitudinal recording method which has spread widely now tends to realize high side recording density, the problem magnetization / record / accompanying detailed-izing of a record bit] of heat fluctuation and the problem of a raise in coercive force exceeding the record capacity of a recording head will occur. Then, solving these problems, as a means to increase field recording density sharply, vertical magnetic recording is examined and the perpendicular two-layer medium which consists of a soft-magnetism film of high permeability and perpendicular magnetic anisotropy films of a high perpendicular anisotropy as one of the vertical-magnetic-recording media which realizes this is proposed.
[0003] Below, with reference to drawing 51 , the composition of the conventional perpendicular two-layer medium is explained. Drawing 51 is the typical substrate cross section of the conventional vertical-magnetic-recording medium. The soft-magnetism backing layer 52 and perpendicular magnetic anisotropy films 54 are formed on a substrate 56 one by one, and the conventional vertical-magnetic-recording medium 50 becomes, as shown in drawing 51 . For example, the CoCr system alloy is used for the soft-magnetism backing layer 52 at a NiFe film and perpendicular magnetic anisotropy films 54, respectively (the Magnetics Society of Japan, Vol.8, No.1, 1984, p17).
[0004]
[Problem(s) to be Solved by the Invention] However, there was a problem which is explained below in the conventional vertical-magnetic-recording medium as shown in drawing 51 . Since the ground soft-magnetism film 52 has magnetic-domain-wall (magnetic domain) structure divided roughly into a BUROHHO line magnetic domain wall and a nail magnetic domain wall, the first problem is the noise (spike noise) of outbreak nature occurring in the case of record reproduction of a vertical-magnetic-recording medium, degrading an envelope property, and checking reproductive fidelity. The noise of such outbreak nature is generated when a head passes through the upper part of the magnetic domain wall produced on the ground soft-magnetism film 52. The second problem is the instability of the record magnetization by the external suspension magnetic field. Since the ground soft-magnetism film 52 has magnetic-domain-wall structure, the magnetic domain wall in the ground soft-magnetism layer 52 moves easily by the external suspension magnetic field. If movement of such a magnetic domain wall takes place in the field in the ground soft-magnetism layer 52 corresponding to the main pole of the perpendicular magnetic head, demagnetization of the magnetization recorded on the perpendicular magnetic anisotropy films 54 which function as a vertical recording layer, or a demagnetization phenomenon will occur. The suspension magnetic field from such the outside is generated from the motor side for the disk rotation in the magnetic disk drive arranged in the magnetic disk and the position which approached, the motor side used for head positioning. Since these magnetic fields may induce magnetic-domain-wall movement of a ground soft-magnetism film and may demagnetize or demagnetize record magnetization when it concentrates at the nose of cam of the main pole of the perpendicular magnetic head although it is very feeble, they serve as a defect fatal as an information storage device.
[0005] Then, the purpose of this invention is to offer the vertical-magnetic-recording medium of new composition so that demagnetization or the demagnetization phenomenon of the noise of the outbreak nature which the envelope property at the time of record reproduction is excellent in, and originates in movement of the magnetic domain wall of a ground soft-magnetism film, and record magnetization may not arise.
[0006]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, in the vertical-magnetic-recording medium which has at least a substrate, the soft-magnetism film prepared on the substrate, and the perpendicular magnetic anisotropy films prepared on the soft-magnetism film, a soft-magnetism film is formed as non-magnetic-domain-wall structure, and the vertical-magnetic-recording medium concerning this invention is characterized by the coercive force being 300 or less Oes. By this invention, the soft-magnetism film of non-magnetic-domain-wall structure means a soft-magnetism film without magnetic-domain-wall structure.
[0007] In order to form the soft-magnetism film of non-magnetic-domain-wall structure, a soft-magnetism film is formed with

FeSiAl or a FeSiAl system alloy. Moreover, you may form a soft-magnetism film with FeTaN or a FeTaN system alloy. Furthermore, you may form the soft-magnetism film of a granular thin film. In that case, the granular thin film is formed by either of the matrix elements of the matrix which constituted as a line the material of the particle which SiO2 or C is used [particle] as the base material of a granular thin film, and it considers [particle] as the material of the particle which distributes either Co, CoPt and CoCrPt in a base material, and makes a train and mother existence distribute a base material.

[0008] Since the granular thin film is distributing other matter in a base material, generally surface smooth nature is seldom excellent. Then, the junction layer of 100nm or less of thickness is made to intervene between a soft-magnetism film and perpendicular magnetic anisotropy films preferably by the vertical-magnetic-recording medium of this invention. By this, the improvement in the surface smooth nature of a soft-magnetism film and improvement in the perpendicular stacking tendency of perpendicular magnetic anisotropy films can be attained simultaneously, and the remanence ratio of the magnetic properties of perpendicular magnetic anisotropy films can be improved, low medium noise-ization can be attained, and it can consider as the good medium of record reproducing characteristics. It is desirable to form a junction layer by either Co1-X Crx (0.25<=x<=0.60), Ti and CrTi in that case.

[0009] Either Cr film of 500nm or less of thickness, V film and Cu film are made to intervene between a granular thin film and a substrate suitably by the vertical-magnetic-recording medium which uses a granular thin film as a soft-magnetism film. Since independent-ization of the particle distributed in the base material can be promoted by this compared with the case where Cr film, V film, or Cu film is not inserted, coercive force increases, improvement in the recording density dependency of a reproduction output can be aimed at, and it is possible to consider as the good medium of record reproducing characteristics. Moreover, a granular thin film is suitably made into non-magnetic-domain-wall structure.

[0010] Although magnetic-domain-wall structure is divided roughly into the BUROHHO line magnetic domain wall and the nail magnetic domain wall, the vertical-magnetic-recording medium concerning this invention equips the bottom of perpendicular magnetic anisotropy films with the soft-magnetism film which does not have such magnetic-domain-wall structure by specifying the membrane formation material of a soft-magnetism film. Therefore, many problems which had been generated to the conventional vertical-magnetic-recording medium using the soft-magnetism film which has magnetic-domain-wall structure, Namely, the noise of the outbreak nature generated when it passes through the upper part of the magnetic domain wall which the perpendicular magnetic head has produced on the soft-magnetism film (spike noise), Or by the suspension magnetic field generated from the motor side for disk rotation, the motor side for head positioning, etc., the magnetic domain wall of a soft-magnetism film can move, the problem of demagnetizing or demagnetizing record magnetization can be solved fundamentally, and the medium of a low noise with a good envelope property can be realized.

[0011]

[Embodiments of the Invention] The example of an operation gestalt is given to below, and the gestalt of operation of this invention is explained to it concretely and in detail with reference to an accompanying drawing.

The example of the example book operation gestalt of an operation gestalt is one example of the operation gestalt of the vertical-magnetic-recording medium concerning this invention, and drawing 1 (a) is the typical substrate cross section showing the composition of the vertical-magnetic-recording medium of this example of an operation gestalt. The vertical-magnetic-recording medium 20 of this example of an operation gestalt is equipped with perpendicular magnetic anisotropy films, a substrate 22, and the ground soft-magnetism film 24 24 of the non-magnetic-domain-wall structure formed one by one on the substrate 22, i.e., the ground soft-magnetism film which does not have magnetic-domain-wall structure, 28, or the becoming laminated structure as shown in drawing 1 (a). a FeSiAl film or a FeSiAl system alloy film, a FeTaN film, or a FeTaN system alloy film -- further SiO2 or C as a material of the particle distributed in the base material as a base material Co, The ground soft-magnetism film which does not have magnetic-domain-wall structure can be formed by adopting CoPt or CoCrPt and using the granular thin film which formed the material of the particle which makes a train and mother existence distribute a base material by either of the matrix elements of the matrix made into the line.

[0012] By the above composition, the vertical-magnetic-recording medium 20 concerning this invention can solve fundamentally many problems which are generated when a ground soft-magnetism film takes magnetic-domain-wall structure and which were mentioned above.

[0013]

[Example] An example is given to below and the gestalt of operation of this invention is explained to it concretely and in detail with reference to an accompanying drawing.

Example 1 this example is one of the examples of the vertical-magnetic-recording medium concerning this invention. Drawing 1 (b) is the substrate cross section showing the composition of the vertical-magnetic-recording medium of this example of an operation gestalt. the ground soft-magnetism film 16 with which the vertical-magnetic-recording medium 10 of this example consists of a FeSiAl film of 500nm of thickness formed on 2.5 inches a substrate 12 and a substrate 12, and Co78Cr19Ta3 film (at%) formed on the ground soft-magnetism film 16 from -- it is formed as a laminated structure which has the becoming perpendicular magnetic anisotropy films 18 and C protective coat (not shown)

[0014] Below, how to produce the vertical-magnetic-recording medium 10 of this example is explained. First, the ground soft-magnetism film 16 which consists of a FeSiAl film of 500nm of thickness on the 2.5 inches substrate 12 on the following membrane formation conditions by the spatter was formed using the 6 inches FeSiAl target.

Initial degree of vacuum of a membrane formation condition chamber : 5x10-7 or less mTorrs substrate temperature : 600-degree-C injection power : 0.5kw argon gas ** : 4mTorr membrane formation speed : 3 nm/sec [0015] Subsequently, the perpendicular magnetic anisotropy films 18 which use Co78Cr19Ta3 (at%) target and consist of Co78Cr19Ta3 film of 100nm of

thickness at the substrate temperature of 200 degrees C on the ground soft-magnetism film 16 which consists of a FeSiAl film were formed. Furthermore, C protective coat of 10nm of thickness was formed on Co78Cr19Ta3 film 18, and the obtained vertical-magnetic-recording medium was used as this invention medium A2. Moreover, the FeSiAl film which formed membranes by carrying out to the room temperature also produced substrate temperature to comparison of coercive force.
[0016] On the other hand, apart from this invention medium A2, the medium which formed the ground soft-magnetism film which consists of a NiFe film like an example 1, and Co78Cr19Ta3 (at%) film was conventionally used as the medium A1 by using a NiFe target instead of a FeSiAl film.
[0017] In order to evaluate the vertical-magnetic-recording medium A2 concerning this invention, observation of magnetic-domain-wall structure, measurement of coercive force, measurement of record reproducing characteristics, etc. were performed as follows. The same evaluation method also as a two or less-example example was applied. In order to investigate the magnetic-domain-wall structure of the FeSiAl film 16 of this invention medium A2, magnetic-domain-wall structure was observed by the powder figure method as follows. First, the very small blemish was given to the front face of the FeSiAl film which formed membranes at the substrate temperature of 600 degrees C, and after making it easy to be visible in magnetic-domain-wall structure, BITTA-liquid (magnetic colloid) was applied on it. And although the sample was set to the electromagnet for magnetic-domain-wall observation and magnetic-domain-wall structure was observed with the metaloscope, clear magnetic-domain-wall structure was not observed. Next, change was not seen when observed impressing a magnetic field to a sample gradually. This was the same also about the FeSiAl film which made substrate temperature the room temperature and formed membranes. Subsequently, similarly, when the NiFe film of a medium A1 was observed conventionally, clear magnetic-domain-wall structure was observed. And when observed impressing a magnetic field to a sample gradually, the situation of movement of a magnetic domain wall was observed clearly. It is shown to the above thing being a magnetization process according [the magnetization process of a NiFe film] to magnetic-domain-wall movement that the magnetization process of a FeSiAl film is not based on magnetic-domain-wall movement.
[0018] Next, in order to investigate the coercive force of a FeSiAl film and a NiFe film, the sample oscillatory-type magnetometer (VSM) was used and coercive force was measured. Consequently, the coercive force of the FeSiAl film which the coercive force of the FeSiAl film which formed membranes at the substrate temperature of 600 degrees C, and a NiFe film made 0.1Oe(s) and substrate temperature the room temperature, respectively, and formed membranes was 300Oe(s).
[0019] The evaluation examination of record reproduction was performed about the medium A1 this invention medium A2 and conventionally using the single magnetic pole head and the ID/MR combined head. here -- ID/MR combined-head recording track width of face -- 4 micrometers regenerative-track width of face -- 3 micrometers record gap length -- 0.4 micrometers and reproduction gap length -- 0.32 micrometers it was . moreover, the width of recording track of a single magnetic pole head -- 10 micrometers main pole thickness -- 0.4 micrometers it was . The evaluation examination was performed under conditions of record current 10mAop, 12mA of sense current, peripheral-velocity 12.7 m/sec, 45nm of flying heights, and 45MHz of band bands of a noise. In addition, the experiment followed in both the case where the signal recorded by the single magnetic pole head is read by the MR head, and the case of reading the signal which recorded with ID head by the MR head. Drawing 2 shows a medium A1 envelope property this invention medium A2 and conventionally. As shown in drawing 2 , this invention medium A2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this evaluation examination was performed by reading the signal recorded by the single magnetic pole head by the MR head, when the evaluation examination which reads the signal recorded with ID head by the MR head was also performed, the difference in the same envelope property was seen.
[0020] In order that the ground soft-magnetism film FeSiAl of this invention medium A2 may not take magnetic-domain-wall structure to the noise of the outbreak nature accompanying movement of a magnetic domain wall being conventionally seen, as for this in order that the ground soft-magnetism film NiFe of a medium A1 may take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the FeSiAl film at the room temperature in a ground will also become the same. It is because magnetic-domain-wall structure cannot be originally made easily if coercive force of the magnetic substance is large, and the coercive force of the FeSiAl film which formed membranes at the room temperature in this case is farther [than the coercive force of the FeSiAl film which formed membranes at the substrate temperature of 600 degrees C] large, and it is because it is in the state where magnetic-domain-wall structure cannot be made much more easily.
[0021] Next, the stability of record magnetization of as opposed to an external suspension magnetic field as follows was evaluated about the medium A1 this invention medium A2 and conventionally. After recording a signal on a medium A1 this invention medium A2 and conventionally by the single magnetic pole head, by Helmholtz coils, the direct-current magnetic field was impressed to the medium in the range of size 0.1-500Oe, the reproduction output before magnetic field impression and the reproduction output after magnetic field impression were measured, and the result was shown in drawing 3 . Drawing 3 shows the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. The fall of the reproduction output accompanying the demagnetization of record magnetization is conventionally seen in the stage which impressed 0.1Oe(s) by which a medium A1 is equivalent to the coercive force of a ground soft-magnetism film so that drawing 3 may show. To the amount of demagnetization increasing in connection with enlarging an impression magnetic field, even if it impressed the magnetic field of 500Oe(s), demagnetization was not seen, but as for this invention medium A2, it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium A2. Moreover, by the method of reading the signal recorded with ID head by the MR head, when the same experiment was conducted, the completely same inclination was seen. This result is shown in drawing 4 .

The result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the FeSiAl film at the room temperature in a ground for a reason which drawing 2 explained by the way also in this case will become the same. However, since the FeSiAl film which formed membranes at the room temperature has coercive force as large as 300Oe(s), distortion produces it in a square wave-like reproduction wave. In order to function as a ground soft-magnetism layer of a perpendicular two-layer medium and to acquire a rectangle-like reproduction wave, as for the coercive force of the ground soft-magnetism film FeSiAl, it is desirable that they are 100 or less Oes.

[0022] Next, the reproduction output was measured, while the single magnetic pole head had been made to load on a medium in order to investigate aging of record magnetization, after recording a signal on a medium A1 by the single magnetic pole head this invention medium A2 and conventionally. The reproduction output immediately after record is made into t = 1 second, and it is t= 1x104. It measured till the second. And the reproduction output at the time of t = 1 second and the reproduction output after fixed time progress were measured, and the result was shown in drawing 5 . Drawing 5 shows the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. By this invention medium A2, the fall of such a reproduction output was not conventionally seen for the medium A1 at all to a reproduction output declining in proportion almost] to the logarithm of the elapsed time after signal record so that drawing 5 might show. The magnetic domain wall of NiFe moves easily also by very small magnetic fields, such as earth magnetism and a motor side for disk rotation, and since it happened in the main pole of the perpendicular magnetic head, and the corresponding field, this is considered that the demagnetization of record magnetization was seen. It is thought that the FeSiAl film used for this invention medium A2 was, on the other hand, able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the FeSiAl film at the room temperature in a ground for a reason which drawing 2 explained by the way also in this case will become the same.

[0023] By using this invention medium A2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0024] Except for having formed the FeSiAlRuTi film on the substrate as a ground soft-magnetism film, like this invention medium A2 of an example 1, the vertical-magnetic-recording medium was produced and it considered as this invention medium B-2 using the example 2FeSiAlRuTi film target. Moreover, the FeSiAlRuTi film which made substrate temperature the room temperature and formed membranes for comparison of coercive force was also produced.

[0025] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the FeSiAlRuTi film of this invention medium B-2 was observed. This was the same also about the FeSiAlRuTi film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of the FeSiAlRuTi film of this invention medium B-2 on magnetic-domain-wall movement.

[0026] Next, coercive force was 0.1Oe(s) when the coercive force of the FeSiAlRuTi film of this invention medium B-2 was investigated. Moreover, the coercive force of the FeSiAlRuTi film which made substrate temperature the room temperature and formed membranes was 300Oe(s).

[0027] When the evaluation examination of record reproducing characteristics was performed about this invention medium B-2 and it compared with the medium A1 conventionally, like this invention medium A2 of an example 1, this invention medium B-2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this evaluation examination was performed by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen.

[0028] This shows that generating of the noise of outbreak nature is fundamentally solvable, in order that the ground soft-magnetism film FeSiAlRuTi of this invention medium B-2 may not take magnetic-domain-wall structure. Moreover, the result of the medium which has the film which formed the FeSiAlRuTi film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0029] Next, the stability of the record magnetization to the external suspension magnetic field of this invention medium B-2 was measured, and it was conventionally shown in drawing 6 as contrasted with the medium A1. Drawing 6 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Even if this invention medium B-2 impressed the magnetic field of 500Oe(s) to the medium A1 conventionally to which a reproduction output falls so that drawing 6 might show, demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium B-2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 7 . Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the FeSiAlRuTi film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0030] Next, aging of record magnetization was measured and it was conventionally shown in drawing 8 as contrasted with the medium A1. Drawing 8 shows the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. By this invention medium B-2, the fall of such a reproduction output was not seen at all to the medium A1 conventionally to which a reproduction output falls so that drawing 8 might show. It is thought that the FeSiAlRuTi film which

uses this for this invention medium B-2 was able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the FeSiAlRuTi film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0031] By using this invention medium B-2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0032] Using the example 3FeTaN film target, except for having formed the FeTaN film on the substrate as a ground soft-magnetism film, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium Q2. Moreover, the FeTaN film which made substrate temperature the room temperature and formed membranes for comparison of coercive force was also produced.

[0033] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the FeTaN film of this invention medium Q2 was observed. This was the same also about the FeTaN film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a FeTaN film on magnetic-domain-wall movement.

[0034] Next, coercive force was 0.1Oe(s) when the coercive force of this invention medium Q2FeTaN film was measured. Moreover, the coercive force of the FeTaN film which made substrate temperature the room temperature and formed membranes was 300Oe(s).

[0035] When the evaluation examination of record reproducing characteristics was performed about this invention medium Q2 and the envelope property with a medium A1 was compared this invention medium Q2 and conventionally, like this invention medium A2 of an example 1, this invention medium Q2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this examination was performed by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. This shows that generating of the noise of outbreak nature is fundamentally solvable, in order that the ground soft-magnetism film FeTaN of this invention medium Q2 may not take magnetic-domain-wall structure. Moreover, the result of the medium which has the film which formed the FeTaN film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0036] Next, the stability of the record magnetization to the external suspension magnetic field of this invention medium Q2 was measured, and it was conventionally shown in drawing 52 as contrasted with the medium A1. Drawing 52 shows the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. As drawing 52 shows, conventionally to which a reproduction output falls, to a medium A1, even if it impressed the magnetic field of 500Oe(s), demagnetization was not seen, but, as for this invention medium Q2, it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium Q2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 53 . Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the FeTaN film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0037] Next, aging of record magnetization of this invention medium Q2 was measured, and it was conventionally shown in drawing 54 as contrasted with the medium A1. Drawing 54 shows the reproduction output after fixed time progress to ** and the reproduction output at the time of t = 1 second by percentage. By this invention medium Q2, the fall of such a reproduction output was not seen at all to the medium A1 conventionally to which a reproduction output falls so that drawing 54 might show. It is thought that the FeTaN film used for this invention medium Q2 was able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the FeTaN film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same. By using this invention medium Q2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0038] The volume ratio of Co in an example 4 distribution film is set up to about 50%, and it is Co target and SiO2. Using a target, impressing bias voltage to a substrate on the same membrane formation conditions as an example 1 simultaneous -- a spatter -- carrying out -- a substrate top -- the Co-SiO2 distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium C2 Moreover, the Co-SiO2 distribution film which made substrate temperature the room temperature and formed membranes for comparison of coercive force was also produced.

[0039] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the Co-SiO2 distribution film was observed. This was the same also about the Co-SiO2 distribution film which made substrate temperature the room temperature and formed membranes. It is shown to the above thing being a magnetization process according [the magnetization process of a NiFe film] to magnetic-domain-wall movement that the magnetization process of the Co-SiO2 distribution film of this invention medium C2 is not based on

magnetic-domain-wall movement.
[0040] Next, when the coercive force of a Co-SiO2 distribution film was measured, the coercive force of the Co-SiO2 distribution film which the Co-SiO2 distribution film of this invention medium C2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).
[0041] When the evaluation examination of record reproducing characteristics was performed about this invention medium C2 and the envelope property with a medium A1 was compared this invention medium C2 and conventionally, like this invention medium A2 of an example 1, this invention medium C2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the Co-SiO2 distribution film this [whose] is the ground soft-magnetism film of this invention medium C2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the Co-SiO2 distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.
[0042] Next, the stability of the record magnetization to the external suspension magnetic field of this invention medium C2 was measured, and it was conventionally shown in drawing 9 as contrasted with the medium A1. Drawing 9 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 9 shows, even if this invention medium C2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium C2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 10 . Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the Co-SiO2 distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.
[0043] Next, aging of record magnetization of this invention medium C2 was measured, and it was conventionally shown in drawing 11 as contrasted with the medium A1. Drawing 11 has shown the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. By this invention medium C2, the fall of such a reproduction output was not seen at all to the medium A1 conventionally to which a reproduction output falls so that drawing 11 might show. It is thought that the Co-SiO2 distribution film which uses it for this invention medium B-2 was able to solve fundamentally the problem of the demagnetization by such magnetic-domain-wall movement in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the Co-SiO2 distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same. By using this invention medium C2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.
[0044] while setting up the volume ratio of Co in an example 5 distribution film to about 50% and impressing bias voltage to a substrate using Co target and C target -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- a Co-C distribution film -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium D2
[0045] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the Co-C distribution film of this invention medium D2 was observed. This was the same also about the Co-C distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a Co-C distribution film on magnetic-domain-wall movement.
[0046] When the coercive force of a Co-C distribution film was investigated, the coercive force of the Co-C distribution film which the Co-C distribution film of this invention medium D2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).
[0047] When the evaluation examination of record reproducing characteristics was performed about this invention medium D2 and the envelope property with a medium A1 was compared this invention medium D2 and conventionally, like this invention medium A2 of an example 1, this invention medium D2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the Co-C distribution film this [whose] is the ground soft-magnetism film of this invention medium D2 may not take magnetic-domain structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the Co-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.
[0048] The stability of the record magnetization to the external suspension magnetic field of this invention medium D2 was measured, and it was conventionally shown in drawing 12 as contrasted with the medium A1. Drawing 12 has shown the

reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. As drawing 12 shows, conventionally to which a reproduction output falls, to a medium A1, even if it impressed the magnetic field of 500Oe(s), demagnetization was not seen, but, as for this invention medium D2, it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium D2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 13 . Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the Co-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0049] Aging of record magnetization of this invention medium D2 was measured, and it was conventionally shown in drawing 14 as contrasted with the medium A1. Drawing 14 has shown the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium D2, the fall of such a reproduction output was not seen at all so that drawing 14 might show. It is thought that the Co-C distribution film used for this invention medium D2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the Co-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same. By using this invention medium D2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0050] The volume ratio of CoPt in an example 6 distribution film is set up to about 50%, and it is a CoPt target and SiO2. Using a target, impressing bias voltage to a substrate on the same membrane formation conditions as an example 1 simultaneous -- a spatter -- carrying out -- a substrate top -- the CoPt-SiO2 distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it took this invention medium E2

[0051] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the CoPt-SiO2 distribution film was observed. This was the same also about the CoPt-SiO2 distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a CoPt-SiO2 distribution film on magnetic-domain-wall movement.

[0052] When the coercive force of a CoPt-SiO2 distribution film was measured, the coercive force of the CoPt-SiO2 distribution film which the CoPt-SiO2 distribution film of this invention medium E2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0053] When the evaluation examination of record reproducing characteristics was performed about this invention medium E2 and the envelope property with a medium A1 was compared this invention medium E2 and conventionally, like this invention medium A2 of an example 1, this invention medium E2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the CoPt-SiO2 distribution film this [whose] is the ground soft-magnetism film of this invention medium E2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the CoPt-SiO2 distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0054] The stability of the record magnetization to the external suspension magnetic field of this invention medium E2 was measured, and it was conventionally shown in drawing 15 as contrasted with the medium A1. Drawing 15 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 15 shows, even if this invention medium E2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium E2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 16 . Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the CoPt-SiO2 distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0055] Next, aging of record magnetization of this invention medium D2 was measured, and it was conventionally shown in drawing 17 as contrasted with the medium A1. Drawing 17 has shown the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium E2, the fall of such a reproduction output was not seen at all so that drawing 17 might show. It is thought that the CoPt-SiO2 distribution film used for this invention medium E2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the CoPt-SiO2 distribution film at the room temperature in a ground for a reason which the example 1 explained by the

way will become the same. By using this invention medium E2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0056] while setting up the volume ratio of CoPt in an example 7 distribution film to about 50% and impressing bias voltage to a substrate using a CoPt target and C target -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- the CoPt-C distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium F2

[0057] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the CoPt-C distribution film was observed. This was the same also about the CoPt-C distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a CoPt-C distribution film on magnetic-domain-wall movement.

[0058] Next, when the coercive force of a CoPt-C distribution film was measured, the coercive force of the CoPt-C distribution film which the coercive force of this invention medium F2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0059] When the evaluation examination of the record reproducing characteristics of this invention medium F2 was performed and the envelope property of a medium A1 was investigated this invention medium F2 and conventionally, like this invention medium A2, this invention medium F2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the CoPt-C distribution film this whose] is the ground soft-magnetism film of this invention medium F2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the CoPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0060] The stability of the record magnetization to the external suspension magnetic field of this invention medium F2 was measured, and it was conventionally shown in drawing 18 as contrasted with the medium A1. Drawing 18 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 18 shows, even if this invention medium F2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium F2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 19 .

[0061] Next, aging of record magnetization of this invention medium F2 was measured, and it was conventionally shown in drawing 20 as contrasted with the medium A1. Drawing 20 has shown the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium F2, the fall of such a reproduction output was not seen at all so that drawing 20 might show. It is thought that the CoPt-C distribution film used for this invention medium F2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the CoPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0062] By using this invention medium F2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0063] the volume ratio of CoCrPt in an example 8 distribution film -- about 50% -- setting up -- a CoCrPt target and SiO2 while impressing bias voltage to a substrate using a target -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- CoCrPt-SiO2 of 500nm of thickness a distributed film -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium G

[0064] CoCrPt-SiO2 Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the distributed film was observed. This was the same also about the CoCrPt-SiO distribution film which made substrate temperature the room temperature and formed membranes. The above thing is CoCrPt-SiO2. It is shown that the magnetization process of a distributed film is not based on magnetic-domain-wall movement.

[0065] Next, CoCrPt-SiO2 It is CoCrPt-SiO2 which the coercive force of this invention medium G2 made 0.1Oe(s) and substrate temperature the room temperature when the coercive force of a distributed film was measured, and formed membranes. The coercive force of a distributed film was 300Oe(s).

[0066] When the evaluation examination of the record reproducing characteristics of this invention medium G2 was performed

and the envelope property of a medium A1 was investigated this invention medium F2 and conventionally, like this invention medium A2, this invention medium F2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. This is CoCrPt-SiO2 which is the ground soft-magnetism film of this invention medium G2. In order that a distributed film may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, it is CoCrPt-SiO2 by reason which the example 1 explained by the way. The result of the medium which has the film which formed the distributed film at the room temperature in a ground will also become the same.

[0067] The stability of the record magnetization to the external suspension magnetic field of this invention medium G2 was measured, and it was conventionally shown in drawing 21 as contrasted with the medium A1. Drawing 21 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 21 shows, even if this invention medium G2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium G2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 22 .

[0068] Next, aging of record magnetization of this invention medium G2 was measured, and it was conventionally shown in drawing 23 as contrasted with the medium A1. Drawing 23 has shown the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium G2, the fall of such a reproduction output was not seen at all so that drawing 23 might show. CoCrPt-SiO2 used for this invention medium F2 It is thought that the distributed film was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, it is CoCrPt-SiO2 by reason which the example 1 explained by the way. The result of aging of record magnetization of the medium which has the film which formed the distributed film at the room temperature in a ground will become the same.

[0069] By using this invention medium G2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0070] while setting up the volume ratio of CoCrPt in an example 9 distribution film to about 50% and impressing bias voltage to a substrate using a CoCrPt target and C TA-GETTO ** -- the same membrane formation conditions as an example 1 -- simultaneous -- a spatter -- carrying out -- a substrate top -- the CoCrPt-C distribution film of 500nm of thickness -- a ground soft-magnetism film -- carrying out -- membrane formation -- the bottom -- alias -- it removed, the vertical-magnetic-recording medium was produced like the example 1, and it considered as this invention medium H2

[0071] Change was not seen, even if it observed clear magnetic-domain-wall structure not having been observed and impressing a magnetic field to a sample gradually, when the CoCrPt-C distribution film was observed. This was the same also about the CoCrPt-C distribution film which made substrate temperature the room temperature and formed membranes. It is shown that the above thing does not depend the magnetization process of a CoCrPt-C distribution film on magnetic-domain-wall movement.

[0072] Next, when the coercive force of a CoCrPt-C distribution film was measured, the coercive force of the CoCrPt-C distribution film which the coercive force of the CoCrPt-C distribution film of this invention medium H2 made 0.1Oe(s) and substrate temperature the room temperature, and formed membranes was 300Oe(s).

[0073] When the evaluation examination of the record reproducing characteristics of this invention medium H2 was performed and the envelope property of a medium A1 was investigated this invention medium H2 and conventionally, like this invention medium A2, this invention medium H2 has a far beautiful envelope conventionally as compared with a medium A1, and it turns out that the envelope property is very excellent. Although this experiment was conducted by reading the signal recorded by the single magnetic pole head by the MR head, when the experiment which reads the signal recorded with ID head by the MR head was also conducted, the difference in the same envelope property was seen. In order that the CoCrPt-C distribution film this whose] is the ground soft-magnetism film of this invention medium H2 may not take magnetic-domain-wall structure, it is shown that generating of the noise of outbreak nature is fundamentally solvable. Moreover, the result of the medium which has the film which formed the CoCrPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will also become the same.

[0074] The stability of the record magnetization to the external suspension magnetic field of this invention medium H2 was measured, and it was conventionally shown in drawing 24 as contrasted with the medium A1. Drawing 24 has shown the reproduction output after the magnetic field impression to the reproduction output before magnetic field impression by percentage. Conventionally to which a reproduction output falls, to a medium A1, as drawing 24 shows, even if this invention medium H2 impressed the magnetic field of 500Oe(s), demagnetization was not seen, but it turns out that the stability of the record signal over an external suspension magnetic field is far excellent in the direction of this invention medium H2. When carried out also by the method of reading the signal which recorded the same experiment with ID head by the MR head, the completely same inclination was seen. This result is shown in drawing 25 . Moreover, the result of the stability of the record magnetization to the external suspension magnetic field of the medium which has the film which formed the CoCrPt-C

distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0075] Next, aging of record magnetization of this invention medium H2 was measured, and it was conventionally shown in drawing 26 as contrasted with the medium A1. Drawing 26 has shown the reproduction output after fixed time progress to the reproduction output at the time of t = 1 second by percentage. Conventionally to which a reproduction output falls, to the medium A1, by this invention medium H2, the fall of a reproduction output like a medium A1 before was not seen at all so that drawing 26 might show. It is thought that the CoCrPt-C distribution film used for this invention medium H2 was able to solve fundamentally the problem of the demagnetization by magnetic-domain-wall movement like a medium A1 before in order not to take magnetic-domain-wall structure. Moreover, the result of aging of record magnetization of the medium which has the film which formed the CoCrPt-C distribution film at the room temperature in a ground for a reason which the example 1 explained by the way will become the same.

[0076] By using this invention medium H2, prevention of the noise of the outbreak nature originating in the improvement in the envelope property at the time of record reproduction and movement of the magnetic domain wall of a ground soft-magnetism film, demagnetization of record magnetization, or demagnetization can be realized, and realization of high recording density becomes easy from the above thing.

[0077] The volume ratio of CoPt in an example 10 distribution film is set up to about 50%, and it is a CoPt target and SiO2 by the spatter. A spatter is simultaneously carried out on the following membrane formation conditions, impressing bias to a substrate using a target, and it is CoPt-SiO2 of 500nm of thickness. Membranes were formed on the 2.5 inches substrate by using a distributed film as a ground soft-magnetism film.

Initial degree of vacuum of a membrane formation condition chamber : 5x10-7 or less mTorrs injection power : 0.5kw argon gas ** : 4mTorr substrate temperature : 600-degree-C membrane formation speed : 3 nm/sec [0078] Co65Cr35 (at%) A target and Co78Cr19Ta3 (at%) A target is used and it is CoPt-SiO2. Co65Cr35 film was formed by thickness 0, 10, 20, and 50,100 and 120nm at the substrate temperature of 200 degrees C on the distributed film, respectively, and Co78Cr19Ta3 film was continuously formed by 100nm of thickness on it. And the medium which formed 10nm of C protective coats, used as this invention medium J2 the medium which set Co65Cr35 film to 100nm, and set Co65Cr35 film to 0nm, namely, has not prepared Co65Cr35 film on it further was conventionally used as the medium B1.

[0079] In order to evaluate the property of this invention medium J2, surface smooth nature, a perpendicular stacking tendency, holding power, record reproducing characteristics, etc. were measured by the following evaluation methods. The same evaluation method was applied also to the 11 or less-example example. The surface smooth nature Ra of Co65Cr35 film of this invention medium J2 was measured under the magnetic-force microscope (AFM), and the result shown in drawing 27 was obtained. It is the value 2 at the time of 0nm of thickness, i.e., CoPt-SiO. It is the value of Ra of a distributed film front face. As drawing 27 shows, it turns out that Ra reduces [the thickness of Co65Cr35 film] 10-100nm, and there is the improvement effect of surface smooth nature. However, if 100nm of thickness is exceeded, surface smooth nature will get worse.

[0080] In order to investigate the perpendicular stacking tendency of Co78Cr19Ta3 film which has Co65Cr35 film of 0-120nm thickness directly under Co78Cr19Ta3 film, the X diffraction was used, it asked for the half-value width of the rocking curve of a hcp (002) peak, and the result shown in drawing 28 was obtained. As drawing 28 shows, it turns out that the half-value width of a rocking curve falls and the perpendicular stacking tendency of 10-100nm of thickness of Co78Cr19Ta3 film is improving. CoPt-SiO2 Not perpendicular magnetic anisotropy films with Co78Cr19Ta3 perfect film on a distributed film but a 10 to 20nm initial layer exists. [in the initial stage of film formation] However, since the crystal structure of Co65Cr35 film and Co78Cr19Ta3 film is very near, the film which was excellent in the strong crystal stacking tendency of a perpendicular anisotropy from the initial stage of film formation of perpendicular magnetic anisotropy films is formed. However, if 100nm of thickness is exceeded, the half-value width of a rocking curve will increase and the perpendicular stacking tendency of Co78Cr19Ta3 film will get worse.

[0081] Interlayer Co65Cr35 film has the both sides of the improvement effect of the smooth nature of a CoPt-SiO2 distribution film front face, and the improvement effect of the perpendicular stacking tendency of Co78Cr19Ta3 film so that the above thing may show.

[0082] Next, Co78Cr19Ta3 which has Co65Cr35 film of 0-120nm thickness directly under Co78Cr19Ta3 film Membranous magnetic properties were investigated by the Kerr effect measuring device, and the remanence ratio of a major company-loop as shown in drawing 29 was obtained. A remanence ratio is improved for the thickness of Co65Cr35 film with the increase in thickness to 10-100nm so that drawing 29 may show. However, if 100nm of thickness is exceeded, a remanence ratio will fall.

[0083] The evaluation examination of record reproducing characteristics was performed about the medium B1 using the ID/MR combined head this invention medium J2 and conventionally. here -- the recording track width of face of a head -- 4 micrometers regenerative-track width of face -- 3 micrometers record gap length -- 0.4 micrometers reproduction gap length -- 0.32 micrometers it is . Evaluation was performed under conditions of record current 10mAop, 12mA of sense current, peripheral-velocity 12.7 m/sec, 45nm of flying heights, and 45MHz of band bands of a noise. Drawing 30 shows the recording density dependency of a medium noise. this invention medium J2 has a medium noise conventionally smaller than this in all recording density as compared with a medium B1, and it turns out that noise figure is very excellent. That is, it is CoPt-SiO2 by inserting Co65Cr35 interlayer. It was attained simultaneously, and the improvement of the smooth nature of a distributed film front face and the improvement of the perpendicular stacking tendency of Co78Cr19Ta3 film could raise the remanence ratio of the magnetic properties of Co78Cr19Ta3 perpendicular magnetic anisotropy films, could reduce the thickness of an initial layer, and led to low noise-ization. A result with Co65Cr35 interlayer's thickness same [a medium 100nm or less] is obtained.

[0084] Drawing 31 is medium S/N. A recording density dependency is shown. 2-5dB of medium S/N is good, and this shows [in / all recording density / a medium B1 / conventionally / in this invention medium J2] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium K2.
[0085] The volume ratio of CoCrPt in an example 11 distribution film is set up to about 50%, and it is a CoCrPt target and SiO2. It removes having used the target and is CoCrPt-SiO2 of 500nm of thickness at the same membrane formation conditions as an example 10. Membranes were formed on the substrate by using a distributed film as a ground soft-magnetism film. Subsequently, Ti target and Co78Cr19Ta3 (at%) A target is used and it is CoCrPt-SiO2. Ti film was formed by thickness 0, 10, 20, and 50,100 and 120nm at the substrate temperature of 200 degrees C on the distributed film, and Co78Cr19Ta3 film was continuously formed by 100nm of thickness on Ti film. And the medium which formed 10nm of C protective coats, used as this invention medium K2 the medium which set Ti film to 100nm, and set Ti film to 0nm, namely, has not prepared Ti film on Co78Cr19Ta3 film further was conventionally used as the medium C1.
[0086] The surface smooth nature Ra of Ti film was measured, and the result shown in drawing 32 was obtained. It is the value 2 at the time of 0nm of thickness, i.e., CoCrPt-SiO. It is the value of Ra of a distributed film front face. As drawing 32 shows, it turns out that Ra reduces [the thickness of Ti film] 10-100nm, and there is the improvement effect of surface smooth nature. However, if 100nm of thickness is exceeded, surface smooth nature will get worse.
[0087] The perpendicular stacking tendency of Co78Cr19Ta3 film which has Ti film of 0-120nm thickness directly under Co78Cr19Ta3 film was investigated, and the result shown in drawing 33 was obtained. As drawing 33 shows, it turns out that the half-value width of a rocking curve falls and the perpendicular stacking tendency of 10-100nm of thickness of Co78Cr19Ta3 film is improving. CoCrPt-SiO2 Not perpendicular magnetic anisotropy films with Co78Cr19Ta3 perfect film on a distributed film but a 10 to 20nm initial layer exists. [in the initial stage of film formation] However, since Ti film and Co78Cr19Ta3 film have good grid adjustment, the film which was excellent in the strong crystal stacking tendency of a perpendicular anisotropy from the initial stage of film formation of perpendicular magnetic anisotropy films is formed. However, if 100nm of thickness is exceeded, the half-value width of a rocking curve will increase and the perpendicular stacking tendency of Co78Cr19Ta3 film will get worse. An interlayer Ti film is CoCrPt-SiO2 so that the above thing may show. It has the both sides of the improvement effect of the smooth nature of a distributed film front face, and the improvement effect of the perpendicular stacking tendency of Co78Cr19Ta3 film.
[0088] Next, the magnetic properties of Co78Cr19Ta3 film which has Ti film of 0-120nm thickness directly under Co78Cr19Ta3 film were investigated, and the result shown in drawing 34 was obtained. A remanence ratio is improved for the thickness of Ti film with the increase in thickness to 10-100nm so that drawing 34 may show. However, if 100nm of thickness is exceeded, a remanence ratio will fall.
[0089] The evaluation examination of the record reproducing characteristics of a medium C1 was performed this invention medium K2 and conventionally, and the result of the recording density dependency of a medium noise shown in drawing 35 was obtained. this invention medium K2 has a conventionally small medium noise in all recording density as compared with a medium C1, and it turns out that noise figure is very excellent. That is, it is CoCrPt-SiO2 by inserting Ti interlayer. It was attained simultaneously, and the improvement of the smooth nature of a distributed film front face and the improvement of the perpendicular stacking tendency of Co78Cr19Ta3 film could raise the remanence ratio of the magnetic properties of Co78Cr19Ta3 perpendicular magnetic anisotropy films, could reduce the thickness of an initial layer, and led to low noise-ization. A result with Ti interlayer's thickness same [a medium 100nm or less] is obtained from the above thing.
[0090] Drawing 36 shows the recording density dependency of medium S/N. 1-2dB of medium S/N is good, and this shows [in / all recording density / a medium C1 / conventionally / in this invention medium K2] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium K2.
[0091] The volume ratio of CoCrPt in an example 12 distribution film was set up to about 50%, and membranes were formed on the substrate on the same membrane formation conditions as an example 10 except for having used the CoCrPt target and C target by using the CoCrPt-C distribution film of 500nm of thickness as a ground soft-magnetism film. Subsequently, Cr20Ti80 target and Co78Cr19Ta3 (at%) Using the target, Cr20Ti80 film was formed by thickness 0, 10, 20, and 50,100 and 120nm at the substrate temperature of 200 degrees C on the CoCrPt-C distribution film, and Co78Cr19Ta3 film was further formed by 100nm of thickness on Cr20Ti80 film continuously. Subsequently, the medium which formed 10nm of C protective coats, used as this invention medium L2 the medium which set Cr20Ti80 film to 100nm, and set Cr20Ti80 film to 0nm, namely, has not prepared Ti film on Co78Cr19Ta3 film was conventionally used as the medium D1.
[0092] The surface smooth nature Ra of Cr20Ti80 film was measured, and the result shown in drawing 37 was obtained. It is the value of Ra of the value at the time of 0nm of thickness, i.e., a CoCrPt-C distribution film front face. As drawing 37 shows, it turns out that Ra reduces [the thickness of Cr20Ti80 film] 10-100nm, and there is the improvement effect of surface smooth nature. However, if 100nm of thickness is exceeded, surface smooth nature will get worse.
[0093] The perpendicular stacking tendency of Co78Cr19Ta3 film which has Cr20Ti80 film of 0-120nm thickness directly under Co78Cr19Ta3 film was investigated, and the result shown in drawing 38 was obtained. As drawing 38 shows, it turns out that the half-value width of a rocking curve falls and the perpendicular stacking tendency of 10-100nm of thickness of Co78Cr19Ta3 film is improving. Not perpendicular magnetic anisotropy films with Co78Cr19Ta3 perfect film on a CoCrPt-C distribution film but a 10 to 20nm initial layer exists. [in the initial stage of film formation] However, since Cr20Ti80 film and Co78Cr19Ta3 film have good grid adjustment, the film which was excellent in the strong crystal stacking tendency of a perpendicular

anisotropy from the initial stage of film formation of perpendicular magnetic anisotropy films is formed. However, if 100nm of thickness is exceeded, the half-value width of a rocking curve will increase and the perpendicular stacking tendency of Co78Cr19Ta3 film will get worse. Interlayer Cr20Ti80 film has the both sides of the improvement effect of the smooth nature of a CoCrPt-C distribution film front face, and the improvement effect of the perpendicular stacking tendency of Co78Cr19Ta3 film so that the above thing may show.

[0094] Next, the magnetic properties of Co78Cr19Ta3 film which has Cr20Ti80 film of 0-120nm thickness directly under Co78Cr19Ta3 film were investigated, and the result shown in drawing 39 was obtained. A remanence ratio is improved for the thickness of Cr20Ti80 film with the increase in thickness to 10-100nm so that drawing 39 may show. However, if 100nm of thickness is exceeded, a remanence ratio will fall.

[0095] The evaluation examination of the record reproducing characteristics of a medium D1 was performed this invention medium L2 and conventionally, and the result of the recording density dependency of a medium noise shown in drawing 40 was obtained. this invention medium L2 has a medium noise conventionally smaller than this in all recording density as compared with a medium D1, and it turns out that noise figure is very excellent. That is, by inserting Cr20Ti80 interlayer, it was attained simultaneously, and the improvement of the smooth nature of a CoCrPt-C distribution film front face and the improvement of the perpendicular stacking tendency of Co78Cr19Ta3 film could raise the remanence ratio of the magnetic properties of Co78Cr19Ta3 perpendicular magnetic anisotropy films, could reduce the thickness of an initial layer, and led to low noise-ization. Moreover, a result with Cr20Ti80 interlayer's thickness same [a medium 100nm or less] is obtained.

[0096] Drawing 41 shows the recording density dependency of medium S/N. 1-4dB of medium S/N is good, and this shows [in / all recording density / a medium D1 / conventionally / in this invention medium L2] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium L2.

[0097] Cr target was used at the substrate temperature of 600 degrees C by the spatter on the substrate of 132.5 inches of examples, and Cr film was formed by thickness 0, 100, 200, 300, and 400 and 500nm. Subsequently, it is CoPt-SiO2 of 500nm of thickness on Cr film like an example 10. Distributed film, Co78Cr19Ta3 film of 100nm of thickness and C protective coat of 10nm of thickness are formed. The medium which inserted Cr film of 500nm thickness is used as this invention medium M2, and Cr film is not inserted, but it is CoPt-SiO2. The medium which formed the distributed film and Co78Cr19Ta3 film was conventionally used as the medium E1.

[0098] Next, CoPt-SiO2 with Cr ground A distributed film and CoPt-SiO2 which it does not have The coercive force of a distributed film was measured using the sample oscillatory-type magnetometer (VSM), and the result shown in drawing 42 was obtained. It follows on the increase in the thickness of Cr ground so that drawing 42 may show, and it is CoPt-SiO2. The coercive force of a distributed film increases.

[0099] On the same reproduction conditions as an example 10, the evaluation examination of the record reproducing characteristics of a medium E1 was performed this invention medium M2 and conventionally, and the recording density dependency of a medium noise shown in drawing 43 was acquired. The medium E1 is standardized this invention medium M2 and conventionally by the output value (output value at the time of recording density 10kFRPI in this case) of a solitary wave. this invention medium M2 has attenuation of the output accompanying increase of recording density conventionally slower than this as compared with a medium E1. In other words, this invention medium M2 can obtain the output conventionally higher than a medium E1 to high recording density. CoPt-SiO2 By inserting Cr ground in the bottom of a distributed film, coercive force increased and improvement in the record density dependence of an output was attained.

[0100] Drawing 44 shows the value of medium S/N in recording density 400kFRPI. About 2dB of medium S/N is good, and this shows [in / high recording density / a medium E1 / conventionally / in this invention medium M2] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium M2.

[0101] Replace with Cr film of example 14 example 13, and using V target, form membranes by thickness 0,100,200,300,400 and 500nm, respectively, and, subsequently V film is made to be the same as that of an example 11. A vertical-magnetic-recording medium is produced, the medium which inserted V film of 500nm thickness is used as this invention medium N2, and V film is not inserted, but it is CoCrPt-SiO2. The medium which formed the distributed film and Co78Cr19Ta3 film was conventionally used as the medium F1.

[0102] Next, CoCrPt-SiO2 with V ground as well as an example 13 A distributed film and CoCrPt-SiO2 which it does not have The coercive force of a distributed film was measured and the result shown in drawing 45 was obtained. It follows on the increase in the thickness of V ground so that drawing 45 may show, and it is CoCrPt-SiO2. The coercive force of a distributed film increases.

[0103] Like the example 13, the evaluation examination of the record reproducing characteristics of a medium F1 was performed this invention medium N2 and conventionally, and the recording density dependency of a medium noise shown in drawing 46 was acquired. The medium F1 is standardized this invention medium N2 and conventionally by the output value (output value at the time of recording density 10kFRPI in this case) of a solitary wave. this invention medium N2 has attenuation of the output accompanying increase of recording density conventionally slower than this as compared with a medium F1. In other words, this invention medium N2 can obtain the output conventionally higher than a medium F1 to high recording density. CoCrPt-SiO2 By inserting V ground in the bottom of a distributed film, coercive force increased and improvement in the record density dependence of an output was attained.

[0104] Drawing 47 shows the value of medium S/N in recording density 400kFRPI. About 2dB of medium S/N is good, and this

shows [in / high recording density / a medium F1 / conventionally / in this invention medium N2] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium M2.

[0105] Replace with Cr film of example 15 example 13, and using Cu target, form membranes by thickness 0,100,200,300,400 and 500nm, respectively, and, subsequently Cu film is made to be the same as that of an example 12. The vertical-magnetic-recording medium was produced, the medium which inserted Cu film of 500nm thickness was used as this invention medium P2, and the medium which formed the CoCrPt-C distribution film and Co78Cr19Ta3 film was conventionally used as the medium G1, without inserting Cu film.

[0106] Next, the coercive force of a CoCrPt-C distribution film with Cu ground and the CoCrPt-C distribution film which it does not have was investigated like the example 13, and the result shown in drawing 48 was obtained. The coercive force of a CoCrPt-C distribution film increases with the increase in the thickness of Cu ground so that drawing 48 may show.

[0107] Like the example 13, the evaluation examination of the record reproducing characteristics of a medium G1 was performed this invention medium P2 and conventionally, and the result of the recording density dependency of a medium noise shown in drawing 49 was obtained. The medium G1 is standardized this invention medium P2 and conventionally by the output value (output value at the time of recording density 10kFRPI in this case) of a solitary wave. this invention medium P2 has attenuation of the output accompanying increase of recording density conventionally slower than this as compared with a medium G1. In other words, this invention medium P2 can obtain the output conventionally higher than a medium G1 to high recording density. By inserting Cu ground in the bottom of a CoCrPt-C distribution film, coercive force increased and improvement in the record density dependence of an output was attained.

[0108] Drawing 50 shows the value of medium S/N in recording density 400kFRPI. About 2dB of medium S/N is good, and this shows [in / high recording density / a medium G1 / conventionally / in this invention medium P2] excelling as a magnetic-disk medium dealing with high recording density. That is, realization of high recording density becomes easy by using this invention medium M2.

[0109]

[Effect of the Invention] According to this invention, the vertical-magnetic-recording medium which the noise of outbreak nature, the demagnetization of record magnetization, or the demagnetization phenomenon which the envelope property at the time of record reproduction is raised, and originates in movement of the magnetic domain wall of a ground soft-magnetism film does not generate is realized by preparing the ground soft-magnetism film of non-magnetic-domain-wall structure in the bottom of perpendicular magnetic anisotropy films. Thereby, conventionally, demagnetization of the record magnetization which was the fatal defect of a vertical-magnetic-recording medium, or generating of a demagnetization phenomenon could be prevented fundamentally, and the vertical-magnetic-recording medium excellent in record reproducing characteristics is realized.

[0110] According to the vertical-magnetic-recording medium given in claims 6 and 7, improvement in the surface smooth nature of a ground soft-magnetism film and improvement in the perpendicular stacking tendency of perpendicular magnetic anisotropy films can be simultaneously aimed at by inserting a junction layer between the granular thin film used as a ground soft-magnetism film, and perpendicular magnetic anisotropy films. According to this effect, the remanence ratio of the magnetic properties of perpendicular magnetic anisotropy films has been improved, low medium noise-ization could be attained, and the vertical-magnetic-recording medium excellent in record reproducing characteristics is realized.

[0111] According to the vertical-magnetic-recording medium according to claim 8, by inserting either Cr film, V film and Cu film between the granular thin films and substrates which are used as a ground soft-magnetism film, independence of the particle distributed in the base material compared with the case where Cr film, V film, and Cu film are not inserted can be promoted, and improvement in coercive force can be aimed at. According to this effect, improvement in the recording density dependency of a reproduction output could be aimed at, and the vertical-magnetic-recording medium excellent in record reproducing characteristics is realized.

[Translation done.]